

I shot two specimens of this very beautifully but subdued-coloured *Sibia* in April last, when making the ascent of the peak of Khúnho, Eastern Burraill range, Nágá Hills, at about 8000 feet. The bird appeared pretty numerous, in companies of four to six or eight, haunting the tops of the rhododendron trees, then in full bloom, busily engaged searching for insects in the flowers, and their forehead, chin, and throat were covered thick with the pollen.

In the general distribution of the coloration and form it resembles *S. gracilis*, extremely common in the same locality, but seldom seen there above 6000 feet.

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XXVI.—*On the Theory of the Process of Fermentation.*

By Dr. H. KARSTEN.

CAGNIARD DE LATOUR in 1836 recognized alcoholic fermentation as a physiological process dependent upon living creatures; and I subsequently (in the 'Bot. Zeitung' for 1848 and 1849) indicated the pathological nature of yeast, *i. e.* that the yeast-cells were not true species of plants, as was supposed by Latour (and by Persoon, 1822), but pathological organizations. This view is now, after long discussion, making some way, in opposition to the opinion maintained by the majority of chemists (following Liebig) that fermentation is a purely chemical process quite independent of any vital action.

Although in 1870 Liebig admitted that alcoholic fermentation is dependent on the presence of living yeast-cells, he endeavoured, nevertheless, to preserve his previous opinion to a certain extent, by assuming that it was the fluid contents of the yeast-cells which effected the decomposition of the sugar, &c.

In accordance with the processes of *decay* in which the *oxidation of the albuminous materials* transfers itself to the neighbouring carbon compounds (a view, the incorrectness of which I demonstrated in 'Poggendorff's Annalen,' 1860), the *process of fermentation* is supposed to be dependent upon the decomposition of albuminous unorganized substances (outside the cell according to Liebig's former opinion, but within it according to his present view), which then also seizes upon the surrounding molecules of complex carbon compounds.

But that even this last conception does not accord with the true nature of the process, and that the *products of fermentation* were generated by the *vegetating membrane* of the yeast-cell and not by its fluid contents, had already been demonstrated by me in my memoir on the Chemistry of the Vegetable Cell in 1869.

Probably Liebig would not have taken all these circuitous ways towards the natural explanation of the process of fermentation had he known that the yeast-cells, even though they do not increase (nay, perhaps may diminish) in weight, are yet constantly vitally active and engaged in continual new formation, and that during the growth of their membranes these finally become changed into vegetable acids, lactic acid, succinic acid\*, and, if we may judge by the analogy of other processes, into glycerine, alcohol, carbonic acid, fat, &c.

Pasteur, who has so thoroughly studied the chemical products of alcoholic fermentation, and so greatly increased our knowledge of them, and to whom we are indebted for finally setting free his *confrères* from the long persistent error that fermentation is a purely chemical act—even Pasteur, in his fresh attempt to establish a theory of the process of fermentation ('Comptes Rendus,' 1872), struck upon the same rock, in thinking that the chemical processes of fermentation differ from a number of other phenomena, and especially from the actions of the other vital phenomena, by the circumstance that a much greater weight of the fermentescible substance is decomposed than the weight of the acting ferment amounts to. That this view is erroneous in every respect we see at once if we compare the quantity of nutriment of any animal with the weight of its body, and, on the other hand, consider the continual regeneration of the yeast-cells, which was urged against Liebig in my 'Beitrag zur Geschichte der Botanik' (1870).

Pasteur also believes that this fact of the inferiority of weight of the organized ferment is connected with its nourishment in the absence of free oxygen; and he finds in this the distinguishing characteristic of fermentation as compared with other vital processes. "Fermentation," says Pasteur, "is a special case of a very general phenomenon; nay, we might say that all creatures, under certain conditions, are ferments. If we kill any creature, or organ in any creature, or a group of cells in this organ, by suffocation, by cutting through nerves, &c., the physical and chemical life in them will not immediately cease, it will continue; and when this takes place under such conditions that free oxygen (interior or exterior) is wanting, then the organism, the organ, or the cells will necessarily derive the heat which they require for their processes of nourishment and growth from the substances surrounding them; they will consequently decompose these, and we shall see the peculiar character of fermentations appear, when the amount of heat developed represents the decomposition of a quantity of fer-

\* 'Harz-, Alkohol- und Milchsäuregährung,' 1871, p. 70, from the 'Zeitschr. des oesterreich. Apotheke-Vereines,' 1870-71.

mentescible substances which is distinctly greater than the weight of the substance set in motion by the organism, the organ, or the cells."

Pasteur, who seems here to agree with my opinion (first expressed in the ' *Botanische Zeitung* ' for 1848) as to the vitality and faculty of increase of cells (*e. g.* secretion-cells or *embryonal* tissue-cells) which have become diseased by abnormal conditions of nutrition, nevertheless, led astray by correctly observed but erroneously interpreted facts, mistakes the nature of a whole group of these pathologico-necrobiotic vital processes. The observation that beer-yeast growing upon the surface of a solution of sugar absorbs atmospheric oxygen, and converts it into carbonic acid without producing alcohol, whilst the same yeast when carried beneath the surface of the fluid by shaking produces alcohol as well as carbonic acid, has misled Pasteur to the assumption that oxygen regularly suppresses alcoholic fermentation.

Assuming that Pasteur's statement is correct, and that yeast floating on the surface of a solution of sugar produces no alcohol, this does not prove that oxygen in such small quantities as the fluid dissolves prevents the formation of alcohol, and that the submerged yeast does not come into contact with oxygen. As fermentation is due to continuous regeneration and increase of the yeast-cells, and for the production of cells oxygen must necessarily lend its aid unless all our observations are at fault, Pasteur's proposition that oxygen unconditionally prevents alcoholic fermentation must need modification as follows:—that the unobstructed action of the atmospheric oxygen upon yeast-cells prejudices their property of furnishing alcohol and carbonic acid as products of the assimilation of grape-sugar, inasmuch as it induces the cuticularization of the membrane of the yeast-cells (that is to say, its partial conversion into a resinous, fatty substance). It is well known that masses of yeast, after being dried in the air, furnish more alcohol on distillation than fresh undried yeast; and all sorts of daily experiences with saccharine fruits and solutions seem to stand in opposition to Pasteur's views.

Recently Pasteur has been confirmed in his opinion formed upon the observation of vegetating yeast by the analogous interpretation of a second fact, likewise correctly recognized.

Couverschel long ago (*Poggend. Ann.* xxii. 1831) observed that ripe saccharine fruits, when kept in carbonic acid, were apparently well preserved for a long time, but at last passed into alcoholic fermentation with indications of decay. Pasteur repeated this experiment, and found that plums, grapes, melons, all acid fruits and many others, when kept in

carbonic acid for a time, passed into a state of alcoholic fermentation, whilst they still appeared externally to be perfectly sound and well-preserved. From twenty-four plums which had lain for a few days in carbonic acid, and had almost improved in apparent soundness and firmness of flesh, he obtained 6.5 grms. of absolute alcohol. In this case also Pasteur derives the alcoholic fermentation from the absence of oxygen.

I also obtained an alcoholic distillate from grapes and plums under similar circumstances, not only when they were preserved in carbonic acid, but also in hydrogen or in an air-tight vessel in atmospheric air (in the latter case the oxygen was probably soon converted into carbonic acid by the ripe fruits). Although no trace of mould or other signs of the commencement of decay could be recognized, 36 cub. centim. of distillate contained 2.8 vol. per cent. of alcohol.

Moreover plums which had been kept for an equal time in *pure oxygen* (prepared by the ignition of chlorate of potash with hydrate of potash) also furnished an alcoholic distillate; nay, ripe figs which had lain in ozonized air showed signs of alcoholic fermentation by their odour and the commencement of yeast-formation in their cells. Under these circumstances also, just as when they had lain in carbonic acid and in hydrogen gas, the fruits retained their normal sound appearance for weeks, and were not attacked by mould, whilst other similar fruits lying in the air had long been decayed and mouldy. On those plums which, as described, had been preserved under pure oxygen gas, a partial production of mould had certainly commenced; but for the purpose of distillation twenty-four well-preserved fruits, of perfectly sound appearance, with no signs of mould, were selected. Some similar fruits were examined microscopically, and proved to be free from Fungi in the interior also.

Even in those experiments which furnished a distillate with a neutral reaction, alcohol was obtained, but 1 per cent. less than in those in which carbonic acid was employed. Other grapes and plums which were exposed to the atmosphere showed no trace of alcohol even when distilled over platinum-black.

Consequently the fruits which in other respects appeared sound, were affected and passed into alcoholic fermentation by excessive action of oxygen just as by other gases injurious to the normal assimilative activity, although (to judge from the results of distillation) this occurs rather later in oxygen gas than in the gases employed in the other experiments.

The exclusion of oxygen, therefore, is not the immediate cause of alcoholic fermentation and allied phenomena in the

organs and tissues fitted for them, but the *abnormal processes of development of the embryonal cells contained in the tissue-cells*, called forth by physico-chemical agencies, in the presence of sufficient quantities of grape-sugar or other bodies, corresponding with other processes of fermentation and decomposition. Alcoholic fermentation, therefore, like the other processes of fermentation and decomposition, has its foundation in the necrobiosis of the organs and tissues in question.

The fruits are suffocated in the oxygen gas, and in the other gases employed, just as they are killed in every pure gas, in water free from air, by mechanical injuries, &c.; the normal process of maturation is interrupted, in consequence of which, and the presence of sugar in their cell-fluid, the cellulæ contained in the latter or their endogenous new formations acquire the nature of yeast-cells. In figs and grapes this may be recognized\* very easily even from the form of the yeast-cells thus produced; whilst in plums, as in the gooseberries which I employed formerly (see 'Botanische Zeitung,' 1848) in experiments on fermentation in hydrogen gas, the newly formed cells acquire a globular form.

Even here it is proved that the kind of biological process of the cell-generations which develop themselves within dying tissue-cells is dependent upon the chemical nature of the cell-fluid and the matter and forces acting from without. The *Vibrios* and *Bacteria* do not originate putrefaction, nor does yeast originate fermentation, but rather the forms which the cells acquire are determined by the nature of the nutritive material. If the fluids are predominantly albuminous, putrefaction ensues with *Bacteria* and *Vibrios*; if they are saccharine, fermentation takes place with yeast, as I have demonstrated in my 'Fäulniss und Ansteckung' (1872, p. 2). Nay, according to the different chemical nature of the fluids, variations of these processes will occur, presenting in their course the greatest similarity to the biological processes of normally assimilating secretion-cells. But in reality these morbidly developed cell-generations are completely different in their nature from the latter.

\* In figs we may most easily convince ourselves of the production of yeast-cells within the tissue-cells during the sojourn of the fruit in carbonic acid, if we add to the microscopic section of such a fruit a portion of a solution of cane-sugar or sugar of milk, and then observe it for some time. This object may be cemented down like a microscopical preparation; and it then slowly but surely shows the growth of the yeast-cells. Figs which had lain for eight weeks in carbonic acid without showing any signs of mould or changing much in form and colour, but which had a vinous-acid odour, were especially fitted to exhibit this development of the grape-sugar yeast.

The secretion-cells are subjected to the creative activity of a composite organism, the preservation and regeneration of which they subserve; their task is synthesis. On the contrary it is the office of these ferments to decompose dead and dying organic substances into their simpler compounds, and to prepare them for decay; their task is analysis. To regard these ferment-cells (*Hysterophymata*) as equivalent to perfect organisms shows a complete misconception of their true nature.

Schaffhausen, November 1873.

## PROCEEDINGS OF LEARNED SOCIETIES.

### ROYAL SOCIETY.

May 8, 1873.—Francis Sibson, M.D., Vice-President, in the Chair.

“Contributions to the Study of the Errant Annelides of the Older Palæozoic Rocks.” By H. ALLEYNE NICHOLSON, M.D., D.Sc., M.A., Ph.D., F.R.S.E., Professor of Natural History in University College, Toronto.

In this communication the author endeavours to elucidate the abundant and obscure organic remains which are found so commonly in the Palæozoic rocks, and especially in the Silurian strata of Britain, and which are generally known by the vague and convenient names of “Fucoids,” “Annelide-burrows,” and “tracks.” After expressing his opinion that the first step towards the study of these obscure fossils lies in the provisional grouping and naming of the more marked forms which are already known to exist, the author proceeds to divide the remains under consideration into two great groups. In the first of these groups are those fossils which are truly the *burrows* of marine worms, as distinguished from mere trails and surface-tracks. Some of these burrows (*Scolithus*) are more or less nearly vertical in direction as regards the strata in which they are found; and they are to be looked upon as being true burrows of habitation. In this section are placed the genera *Scolithus*, *Arenicolites*, and *Histioderma*. Other burrows are of a totally different nature from the preceding, and may reasonably be compared to the burrows of the recent lobworms. These burrows run more or less horizontally as compared with the laminae of deposition, or they penetrate the strata obliquely. They are not burrows of habitation, but are wandering tunnels excavated by the worm in its search after food. The fossils of this group, therefore, as preserved to us, are not the actual burrows themselves, but the burrows filled up with the sand or mud which the worm has passed through its alimentary canal. The burrows of this kind (including many forms previously described under the names